THE SHARED SOCIAL SPACE AS A BASIC FACTOR FOR THE DESIGN OF GROUP-WARE

Matthias Rauterberg, Markus Dätwyler and Marc Sperisen

Work and Organizational Psychology Unit
Swiss Federal Institute of Technology (ETH)
Nelkenstrasse 11, CH-8092 Zürich
+41-1-6327082, rauterberg@ifap.bepr.ethz.ch

Abstract

An experiment was performed to test the hypothesis that a shared social space (SSS) with continuous and "rich" communication possibilities leads to co-operative behavior. The DOOM game provides a test environment, where a group of four players have to fight against each other. Two samples of 12 persons were tested playing DOOM: one with the SSS conditions (continuous spoken communication mode, small physical distance among players, no headphones), and another under the condition of separation during the game (discontinuous communication mode: spoken communication only during a break, large physical distance and headphones during the game). During a break all players had have the chance to discuss the outcome of the first trial (group process feedback). The SSS conditions led to a significantly increased amount of coalitions between players. These coalitions, however, seem to be in-stable over time. Group process feedback also had a positive effect on the extent of coalitions.

Keywords

Shared social space, coalition behavior, computer supported co-operative work (CSCW), group-ware, computer game.

1. Introduction

The concept of 'sound space' was introduced by Beaudouin and Gaver [1]. We generalize this concept to 'shared social space' (SSS) for CSCW and group-ware applications. The sound space can be differentiated into a verbal and a non-verbal communication channels. Verbal communication can be, in turn, differentiated into voice (textual information) and intonation (meta-textual information). Non-verbal communication includes (1) information about physical events, (2) information about invisible structures, (3) information about dynamic change, (4) information about abnormal structures, and (5) information about events in space [10]. SSS is characterized by the following three different communication aspects: (1) visibility (e.g., facial expression, gesture), (2) audibility (e.g., voice, intonation, sound), and (3) social nearness (e.g., physical distance).

Patterson and Edinger [9] emphasised the important role of space and distance in social behavior ('social nearness'). A considerable amount of research has focused on the specific effects of distance and arrangements on social interaction. For example, empirical studies show that a moderate distance (5 ft) between two interactants may decrease anxiety and increase verbal productivity relative to close (2 ft) and far (9 ft) distances. The strength of the positive influence of spoken communication on co-operative problem solving was demonstrated by Ochsman and Chapanis [8], but, only the communication process between two persons was investigated. The test design did not allow for the analysis of the process of establishing coalitions.

Rauterberg and Styger [11] showed the positive effect of sound as feedback for invisible events. This study was done in the context of maintaining a plant simulator by one operator. Gaver, Smith and O'Shea [5] presented similar results for the operating and controlling of a bottling plant simulator by two operators connected via video (face and voice information). Hindus and Schmandt [6] investigated the structural effect of acoustical information among two speakers on collaborative behavior in a shared voice channel. The authors were primarily interested in the technical aspects of analysing the conversational structure. It is difficult to define and to measure co-operative behavior precisely. Deutsch [3] defines a *co-operative* social situation such that: the goal-region for each of the individuals in a given situation are defined so that a goal-region can be entered by any given individual only if all the individuals under consideration can also enter their respective goal-regions.

Deutsch [3] defines a *competitive* social situation as follows. The goals for the individuals are characterised by goal-regions where, if a goal-region is entered by any individual, the other individuals will be unable to reach their respective goals. It should be noted that there are probably very few real-life situations where these definitions are 'purely' applicable. With an experimental investigation Deutsch [4] considered the effects of co-operation versus competition on group performance. He found two important practical implications of the results of his study: (1) greater group productivity results when the members are co-operative rather than competitive in their interrelationships; (2) competitiveness produces greater personal insecurity (expectations of hostility from others) than does co-operation.

Bellamy, Cooper and Borovoy [2] investigated the effects of 'conversational props' (e.g., pictures, drawings, video clips) on the learning process of school children. For example, they successfully showed that the sending and receiving video and text messages supports the social construction of knowledge. In a large empirical study with group sizes between three and six persons Losada, Sanchez and Noble [7] found the following three relevant results: (1) if collaborative technology was used *without* feedback of the actual group process, a substantial reduction in socio-emotional interactive sequences was observed; (2) if collaborative technology was used *with* feedback of the actual group process, a significant increase in socio-emotional interactive sequences was observed; (3) if group process feedback was given *without* using the collaborative technology, a significant reduction in socio-emotional interactive sequences was observed. Losada, Sanchez and Noble [7] suggest, "that group process feedback could be instrumental in reducing social dynamics losses in computer-supported collaborative technology." Still, the extent to which SSS ('communication-rich mode') influences the amount of co-operation in teams rather than only the task solving performance (cf. [4] and [8]) or the amount of socio-emotional interactivity (cf. [7]) is unclear.

2. Method

We chose the computer game DOOM for the research context to reconsider the hypothesis that SSS has an influence on the extent of co-operative behavior. This type of game forces the group members to continually choose between co-operative and competitive behavior. DOOM allows a maximum of four players to fight against or to co-operate with each other in the same virtual, highly animated 3-D space. If a player meets another player in the virtual 3D room, then he or she has three possibilities: (1) to fight and -- if possible -- to kill the other, (2) not to fight and -- at least for the actual meeting -- to form a coalition, or (3) to run away or to behave in a passive way (e.g. not to rise after dying). The agreement not to attack each other among at least two players was interpreted as a 'coalition'. A stable coalition can lead to cooperative behavior over time (e.g., to fight together and to protect each other).

A research version of DOOM was implemented such that players could not communicate during the game by keyboard. Therefore the players needed an additional communication channel in order to form a coalition. The analysis of the effects of two different kinds of interactions: (1) continuous versus discontinuous communication and (2) group process feedback versus no feedback was of primary interest.

2.1. Environment

In a computer training room at the ETH with eight IBM PCs connected by Ethernet two separate clusters of four PCs each were networked. One PC cluster was arranged so that all four players sat in a different corner of the room (large distance condition). The other PC cluster was in the center of the room so that each player sat 'side by side' or 'back to back' with the three other players (small distance condition). With the DOOMEdit v4.1 a new 3-D labyrinth was implemented, ie. one room with several separators (walls of different heights and a column). The layout of our 3-D labyrinth was very similar to the ground plane of a real LaserDrome game room near Zuerich. The purpose of a medium-high wall is that one can see over, but cannot go through it. After entering the test room, each player was randomly assigned a coloured badge (COLOR = {grey, green, red, yellow}). Each PC screen has a coloured sheet of paper on top of the screen, as well. All colours corresponded with the colours of the virtual bodies inside the DOOM game. The input device was the keyboard; the output device was the colour screen (IBM, 17").

2.2. Subjects

A total of one female and 23 male persons participated as players. Sixteen persons were students of computer science, and the other eight were public servants, free-lancers or others. A group of eight subjects played together at the same time in the test room. The age of 83% of all subjects was among 21 and 30 years, and the age of the others was among 31 and 40 years. To measure the pre-experiences with the DOOM game and some personality aspects we asked each subject to answer two corresponding questionnaires.

2.3. Task

Each player was instructed as follows: "You are together with three other players in an unknown building. In this game a hit is the killing of a player. Try to get as many hits as you can. Coalitions with one of the others could be -- but are not necessarily -- helpful. You are alone with the three other players at their PCs in the labyrinth ."

2.4. Procedure and independent measures

We used a 2-factorial test design with the following two independent factors. *Factor A:* 'communication mode' (continuous versus discontinuous) was considered to be a measure of SSS. Players under the small distance condition could continuously communicate with each other. Players under the large distance condition had to wear headphones during the game so that they could only com municate during the break (discontinuous communication mode). *Factor B:* 'group process feedback' (trial-1 without feedback versus trial-2 with feedback) was a repeated factor. The whole play time was divided into two trials of 15 minutes each with a break of 10 minutes between them. At the beginning of the break all eight players got group process feedback of their results of trial-1 so that they could take the chance to discuss them during the break. The group process feedback was a diagram with the number of killings (who killed whom, marked by the four colours). We gathered players with a list on a billboard outside the test room. All eight players of a group were randomly assigned to one of the eight positions. On three days in a row, three different groups were investigated.

2.5. Dependent measures

First, the results of the main dependent variable 'coalition' are presented. With individual questionnaires all players after both trials were asked whether (or not) they had have a coalition with one or more other players and if yes, with whom (given by the colour). A coalition was coded as "1" and no coalition as "0". Second, to validate the users' answer in the questionnaire their real behavior was measured by the number of killings per trial ('# of killings'). With this data we calculated a second dependent variable:

$$\text{The 'traitor rate'} = \sum_{c \in \text{COLOR}} \text{'coalition'}_c * \text{'\# of killings'}_c$$

If the value of 'coalition' is '0' (no coalition), then the 'number of killings' of another player can be greater '0' (no traitor case). But, if the value of 'coalition' is '1' (coalition) and the 'number of killings' of the ally is greater 0, then we have a 'traitor'. The 'traitor rate' is a sensible measure of the stability of a declared coalition during a trial. The greater the 'traitor rate' is, the less stable is the coalition during the trial.

The third dependent measure 'position' is the physical -- and therefore social -- relation between the players' seats ('side by side' versus 'back to back'). In the setup, there were eight different seats: four 'side by side' places (small distance: 'yellow and red' versus 'grey and green'; large distance: 'yellow and green' versus 'red and grey') and four 'back to back' places (small distance: 'yellow and grey versus 'red and green'; large distance: 'yellow and red' versus 'green and grey'). If the aspect of 'social nearness' has an important contribution to the process of establishing a coalition, then the 'side by side' players should have a greater chance to form a coalition than the 'back to back' players.

3. Results

We analysed our data with the statistic tool StatView (version 4.02). The results of the three factorial analyses of variances with one repeated measurement (Factor B 'group process feedback') are as follows: (1) The Factor 'communication' is significant (df=1, F=17.7, $p \leq .0004$), and (2) the factor 'group process feedback' is also significant (df=1, F=16.8, $p \leq .0005$); and (3) no significant interaction term between 'communication' and 'feedback' (df=1, F=0.47, $p \leq .501$). Continuous spoken communication with small distance and high social nearness (the SSS condition) leads to an increased amount of coalitions (see Table 1).

Table 1: Factor 'communication mode' -- means of 'coalition'.

	Count	Mean	Std. Dev.
continuous	24	.625	.495
discontinuous	24	.208	.415

Table 2: Factor 'group process feedback (fb)' -- means of 'coalition'.

	Count	Mean	Std. Dev.
without fb (trial 1)	24	.167	.381
with fb (trial 2)	24	.667	.482

After the first trial and the group process feedback an significantly increased amount of coalitions can be observed (see Table 2). Communication in the shared social space during the break had a strong impact on coalitions in the second trial. But, group process feedback and communication during the break did not compensate the effect of continuous communication and social nearness (no significant interaction).

The stability of a coalition -- measured with the 'traitor rate' -- is significantly different at the 6%-level among the continuous and the discontinuous communication mode (df=1, F=3.93, $p \leq .0599$; see Table 3). The factor 'group process feedback' showed no significant difference (df=1, F=0.144, $p \leq 708$; see Table 4). There is also no significant interaction term between factor 'communication' and factor 'feedback' (df=1, F=0.698, $p \leq .413$).

Players under the SSS condition have a high amount of coalitions (see Table 1), but they change these coalitions during the game (see Table 3). It is important to notice that the effect of the Factor 'group process feedback' is not significant. Because the variances of the 'traitor rates' among both conditions of Factor 'communication mode' are quite different (see Table 3), this effect was re-tested and nearly confirmed with the Mann-Whitney test (U = 200.5, $p \leq .0712$). We interpret this result as a tendency toward increasing instability of coalitions.

Table 3: Factor 'communication mode' -- means of 'traitor rate'

	Count	Mean	Std. Dev.
continuous	24	1.417	2.873
discontinuous	24	.125	.448

Table 4: Factor 'group process feedback (fb)' -- means of 'traitor rate'.

	Count	Mean	Std. Dev.
without fb (trial 1)	24	.875	2.833
with fb (trial 2)	24	.667	1.129

The variable 'number of killings' can not explain the results of the variable 'traitor rates'. A significant difference for the variable 'number of killings' was not found, neither among both communication modes (df=1, F=0.386, $p \leq .542$) nor among without and with group process feedback (df=1, F=0.014, $p \leq 908$).

To verify the interpretation that the aspect of 'social nearness' of SSS is one critical factor (not the continuous voice communication aspect alone), the correlation between the 'communication mode' and the 'social nearness' (seating position) was analysed. We can find a significant correlation between the Factor 'communication mode' (continuous versus discontinuous) and the variable 'position' ('side by side' versus 'no coalition') during the first trial (df = 1, CHI square = 4.8, $p \leq .029$). Due to spareness the level 'back to back' was excluded in this analysis.

A significant correlation was also found between the Factor 'communication mode' (continuous versus discontinuous) and the variable 'position' ('side by side' versus 'back to back' versus 'no coalition') during the second trial (df = 2, CHI square = 11.1, $p \leq .004$).

4. Conclusions

Three questions were investigated in our experiment: (1) How does a shared social space influence the readiness to change from competitive to co-operative behavior? (2) How does a group process feedback influence the readiness to change from competitive to co-operative behavior? (3) Does the aspect of social nearness -- in the context of a communication rich mode -- make an independent contribution? With this investigation, the strong influence of continuous spoken communication -- based on a shared social space -- on the extent and stability of co-operative behavior was shown. Not only the shared sound space, but also the shared social space and group process feedback (e.g., discussions during breaks provoked by the game results) increased the readiness to form a coalition. Due to the type of game the stability of each coalition cannot be stable over a long time. Social isolation during task solving leads to a low coalition rate and should be avoided in the context of CSCW and group-ware applications. If no spoken communication channel is established among users, then the wearing of a headphone is one technical factor for social isolation.

5. References

[1] BEAUDOUIN-LAFON, M. & GAVER, W. (1994) ENO: Synthesizing Structured Sound Space. in Proceedings of UIST'94. (pp. 49-57), New York: ACM.

[2] BELLAMY, R., COOPER, E. & BOROVOY, R. (1994) Supporting collaborative learning through the use of electronic conversational props. in B. Blumenthal, J. Gornostaev & C. Unger (Eds.) Human Computer Interaction. (Lecture Notes in Computer Science, Vol. 876, pp. 181-191), Berlin: Springer.

[3] DEUTSCH, M. (1949) A theory of co-operation and competition. Human Relations 2: 129-152.

[4] DEUTSCH, M. (1949) An experimental study of the effects of co-operation and competition upon group process. Human Relations 2: 199-231.

[5] GAVER, W., SMITH, R. & O'SHEA, T. (1991) Effective sounds in complex systems: the ARKola simulation. in S. Robertson, G. Olson and J. Olson (Eds.) CHI'91 Conference Proceedings "Reaching through Technology". (pp. 85-90), Reading MA: Addison-Wesley.

[6] HINDUS, D. AND SCHMANDT, C. (1992) Ubiquitous Audio: Capturing Spontaneous Collaboration. in Proceedings of the Conference on Computer-Supported Cooperative Work – CSCW'92. (pp. 210-217), New York: ACM.

[7] LOSADA, M., SANCHEZ, P. & NOBLE, E. (1990) Collaborative technology and group process feedback: their impact on interactive sequences in meetings. in Proceedings of the Conference on Computer-Supported Co-operative Work. – CSCW'90. (pp. 53-64), New York: ACM.

[8] OCHSMAN, R. & CHAPANIS, A. (1974) The effects of ten communication modes on the behavior of teams during co-operative problem solving. International Journal of Man Machine Studies 6:579-619.

[9] PATTERSON, M. & EDINGER, J. (1987) A functional analysis of space in social interaction. in A. Siegman and S. Feldstein (Eds.) Nonverbal behavior and communication. (pp. 523-562), Hillsdale: Erlbaum.

[10] MOUNTFORD, S. & GAVER, W. (1990) Talking and Listening to Computers. in B. Laurel and S. Mountford (Eds.) The Art of Human-Computer Interface Design. (pp. 319-334), Reading, MA: Addison-Wesley.

[11] RAUTERBERG, M. & STYGER, E. (1994) Positive effects of sound feedback during the operation of a plant simulator. in B. Blumenthal, J. Gornostaev & C. Unger (Eds.) Human Computer Interaction. (Lecture Notes in Computer Science, Vol. 876, pp. 35-44), Berlin: Springer.

SCHRIFTENREIHE DER ÖSTERREICHISCHEN COMPUTER GESELLSCHAFT
BAND 82

Klaus Brunnstein, Peter Paul Sint

Intellectual Property Rights and New Technologies

Proceedings of the KnowRight'95 Conference

R. Oldenbourg Wien München 1995